Processes Controlling Transfer of Fine-Grained Sediment Within and Between Channels and Flats on Intertidal Flats

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Award Number: N00014-08-1-0759 & N00014-08-1-0789
http://tidalflats.org

LONG-TERM GOALS

A long-term goal of the sediment transport and accumulation investigations is to link sediment-transport processes to the formation and preservation of event beds in sediment deposits. The general goal of this project is to investigate how forcing processes (e.g., tidal asymmetry) cause sediment transport that imports fine-grained sediment to form the mud-flat environment with its complex morphology (e.g., multiple scales of tidal channels and different elevations of flats). This project investigates processes that transfer fine-grained sediment within and between channels and flats in intertidal settings, and relates them to the temporary and longer-term deposits found in those environments – when, why and how do suspended sediments transfer from the loose, unconsolidated (possibly fluid mud) deposits to and from the flat environments.

Specifically, we are trying to answer the question: What role do tidal (diurnal, and spring/neap), riverine and other seasonal (winds/waves, temperature, and biological glue) processes have on the transfer of sediment between the flats and channels and within the channels and how is this manifested in terms of channel and flat deposits (temporary and longer)?

OBJECTIVES

Previous work by me and others in shallow tidal environments and on tidal flats lead to the following conceptual model of tidal-flat sediment-transport processes:

> Tidal asymmetry causes flood tidal currents to generate boundary-layer processes and water-column mixing that pump fine sediment onto the flats. Ebb tidal currents deliver sediment from smaller tributary channels to major distributary channels where high-concentration processes either store or episodically transfer sediment from the system – the net sum of these processes varies temporally and spatially over intertidal flats.

A simple conceptual model shows the dominant processes involved in the sediment cycling on tidal flats (Figure 1). We can think of this model at various timescales in terms of a budget of sediment that includes the input from rivers, the import/export at the seabed, and the cycling of sediment in and out

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **2008**	2. REPORT TYPE	3. DATES COVERED **00-00-2008 to 00-00-2008**

4. TITLE AND SUBTITLE **Processes Controlling Transfer of Fine-Grained Sediment Within and Between Channels and Flats on Intertidal Flats**	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **School of Oceanography,Box 357940,Seattle,WA,98195**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**6**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

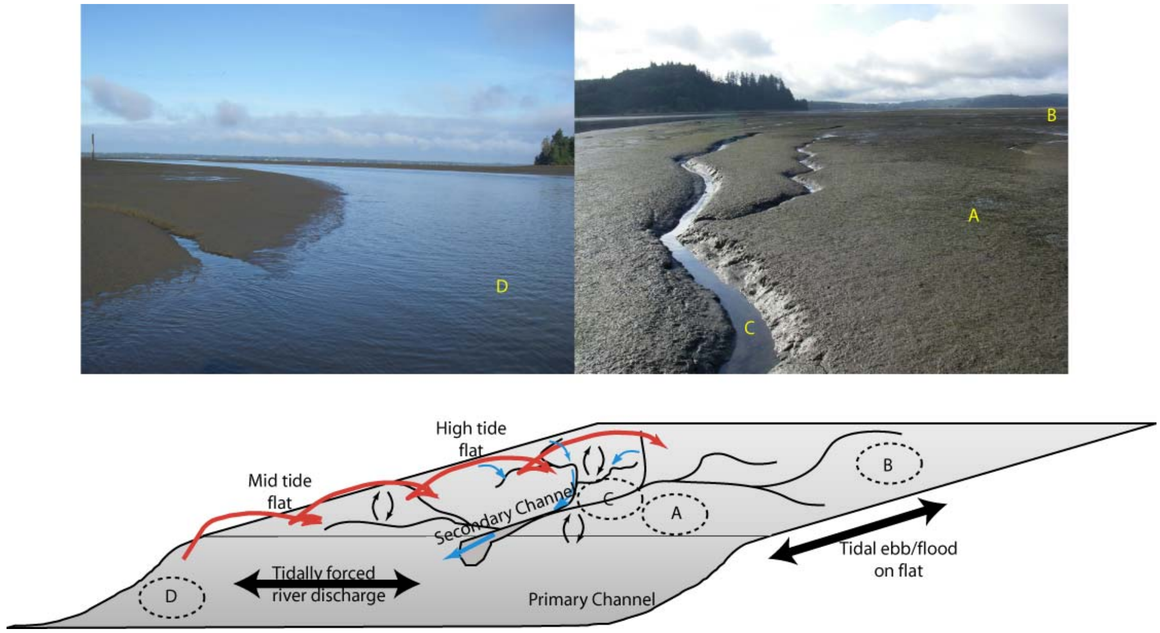

Figure 1. Photos from Willapa Bay, and simplified cartoon of different tidal-flat environments proposed to be studied. Characteristic environments to be instrumented are shown in both the photos and the conceptual diagram: A) mid flat, B) high flat, C) secondary channel, and D) primary channel/river. The arrows indicate processes hypothesized to be active on the tidal flat. Red arrows indicate shoreward tidal pumping, small black arrows indicate resuspension on the tidal flat, blue arrows indicate delivery and trapping in the secondary channel environments, and delivery back to the river system through the primary distributary channels.

of each sub-environment. To address the hypothesis, our studies will achieve the following objectives over time scales from tidal (semidiurnal, fortnightly, and lunar monthly), to event (e.g., wind storms), to seasonal, and potentially to interannual:

1. Water Column. Evaluate water-column sediment-flux factors such as currents, suspended-sediment concentrations and sediment characteristics on tidal flats in key environments (on the mid-flat, in secondary tidal distributary, and in the adjacent primary tidal/river channel), and how the flux is distributed in the water column (e.g., temporary fluid muds that get mixed into the water column).

2. Seabed. Relate seabed changes in porosity and grain size (resulting from deposition, erosion, bioturbation and dehydration) to the water-column sediment-flux dynamics through observation of seabed elevation changes and close interaction with participants exploring seabed processes.

3. Environmental Linkages. Determine the connections between environments through spatial studies of sediment flux and suspended-sediment characteristics.

4. Scientific Interactions. Collaborate with other participants to investigate the spatial variations in transport processes on the tidal flat. This includes participants who will be evaluating relationships between remotely observed signatures and active sediment-transport processes, and participants who will be using models to predict three-dimensional dispersal of sediment and evolution of seabed characteristics.

APPROACH

Tidal-flat studies require specialized sensors and platforms designed to capture the processes and products without impact to the soft seabed. For time-series studies, we will deploy instrument suites on pipes vibrated into the seabed, or on small frames that have minimal impact to the sediment-water interface – a hybrid of surf-zone deployment structures and shelf tripods. An important aspect of these deployment methods is the capability to maintain sensors without impact to the seabed, particularly in the muddy environment of Willapa Bay. We are testing methods that allow us to access instrumentation at high to mid tides from a small boat, or jack-up platform, leaving the seabed undisturbed.

Instrument suites to address the objectives of this project consist of an ADV current meter for high-resolution current, wave and bed-elevation measurements; FOBS (fiber optic backscatter system) sensors spanning the variable-depth water column for suspended-sediment concentration (see below); and an acoustic altimeter for seabed elevation. The newly developed FOBS sensors measure suspended-sediment concentration at 20 elevations above the bed and provide bed-elevation information as sensors get partially and then fully buried within the seabed (~5 mm resolution). Video systems for sediment size and settling velocity estimates (Sternberg et al., 1996) will be located at multiple sites, and we will augment that information with a strategically placed LISST.

Spatial profiling has been a limited aspect of previous tidal-flat studies, and therefore the understanding of how processes vary between locations is lacking. We are using a small profiling system that can be deployed from a moveable platform (small boat or coring platform) with sensors to measure water-column stability, velocity, suspended-sediment concentration, and particle characteristics (in situ suspended-sediment samples). An existing profiler built at UW has been used in shallow, tidal systems previously (Martin et al., 2008; Ogston et al., 2008). A pump sampling mechanism to validate sediment-concentration calibrations and sensors to explore changes in grain size along transport pathways is essential. This system is being modified for work from a moveable platform on the tidal flat.

WORK COMPLETED

Field work was initiated in the first summer (August/September 2008) of this project. The following field efforts were undertaken:

1. Willapa Bay –

Figure 2. Long-term monitoring station on Willapa tidal flats. The site is located on the Bear River channel near Round Island and data will be provided to participants in the Tidal Flats DRI. Spatial profiling on 9-12 September 2008 at locations near the Bear River channel and Central channel showed salinities ranging from 25 to 28.

A long-term monitoring station was installed on the southern tidal flats of Willapa Bay (Figure 2). This station will be maintained over the year (or more) of field studies conducted by participants in this location. The instrumented system will collect information on currents, tides, waves, salinity, temperature, suspended-sediment concentration and characteristics, and seabed accretion/erosion.

Spatial studies of currents, salinity, temperature and suspended-sediment concentration were conducted over the flats with focus on the Bear River and Central channels. These studies helped to determine the site of the long-term station, and will provide preliminary data to plan further focused studies on the southern Willapa flats.

2. Skagit Bay –

a. Shallow intertidal processing

Two small instrumented tripods were deployed on the outer Skagit tidal flats in a pilot study coordinated with an NSF project investigating ecosystem dynamics. This field effort confirmed that the small instrument sets are an appropriate deployment technique for the study, but biofouling by floating algal mats is an issue that will need to be addressed by all participants at this location. Currents were predominantly tidal in this neap to spring tide study, and showed a net northward along-isobath flow (Figure 3) and salinities that ranged from 10 to 24 in the shallow waters of the flat (0-3 m depth).

b. Export of sediment from the Skagit tidal flats

Water-column profiling and ADCP surveys were conducted from the *R/V Barnes* as part of a cruise to Skagit Bay to investigate the fate of the fine-grained fraction of Skagit River sediment and the export of sediment from the Skagit tidal flats. The river flow was low (~8500 cfs), yet the plume was

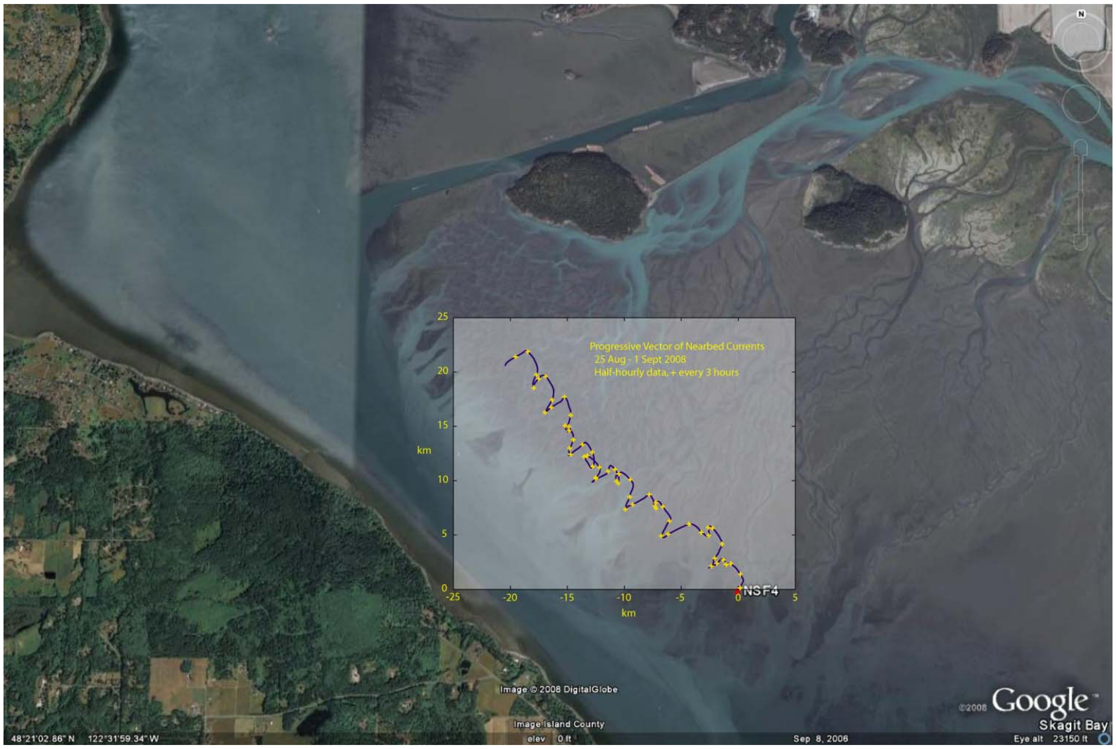

Figure 3. Preliminary progressive vector diagram of currents on the outer Skagit flats near the North Fork of the Skagit River. In this time period (25 August – 1 September 2008), net currents were along-isobath to the north, and salinities ranged between 10 and 24.

distinctive, and identified through Saratoga Pass and approaching Deception Pass. Suspended-sediment concentrations were minimal in the surface plume, and a terrigenous bottom nepheloid layer was identified in the Saratoga Passage and Skagit Bay areas.

RESULTS

New Start in FY2008, see preliminary results incorporated into “Work Completed” section.

IMPACT/APPLICATIONS

To understand the source-to-sink sediment transfer from rivers to marine deposition, we must develop our understanding of the gateway between the land and ocean -- shallow-water regions spanning the tidally influenced river to the inner shelf. It is at this interface that the processes that transport and package sediment in suspension undergo dramatic changes. Tidal flats are one type of environment found in this shallow-water realm. The transport and deposition of fine-grained sediment varies over the global range of tidal flats and may be predominantly importing or exporting sediment, yet our understanding of why these differ is limited.

This study will provide valuable collaborations with other research groups, particularly by providing dynamic measurements in Willapa Bay. Understanding the transport regime is integral to understanding the properties of the seabed. Additional sensors (from my inventory or from those of other investigators) can, and will, be added to the deployment plan. Remotely sensed circulation and sediment flux can be ground-truthed with observations obtained with the in situ sensor systems. The data will provide validation for modeling and laboratory studies concerning transport on tidal flats. The year-long monitoring package allows the group to monitor and observe during less-frequent events, and will aid the interpretation of imagery that will be obtained on monthly or rapid-response overflights.

RELATED PROJECTS

The Tidal Flats DRI projects are tightly knit. This work will provide interactions with all participants through meetings, shared results and scientific discussions. We will share our data with all interested Tidal Flats DRI scientists.

Specifically, the data collected through this project will be interpreted in conjunction with C. Nittrouer's investigation entitled "Documenting Fine-Sediment Import and Export for Two Contrasting Mesotidal Flats" through a shared graduate student.

REFERENCES

Martin, D.P., Nittrouer, C.A., Ogston, A.S., Crockett, J.S. (2008) Tidal and seasonal dynamics of a muddy inner-shelf environment, Gulf of Papua. *Journal of Geophysical Research.* doi:10.1029/2006JF000681.

Ogston, A.S., Crockett, J.S., Goni, M.A., Martin, D.P., Nittrouer, C.A., Sternberg, R.W., (2008) Sediment delivery from the Fly River tidally dominated delta to the nearshore marine environment and the impact of El Nino. *Journal of Geophysical Research.* doi:10.1029/2006JF000669.

Sternberg, R.W., A.S. Ogston, and R.V. Johnson (1996) A Video System for in-situ Measurement of Size and Settling Velocity of Suspended Particulates, *Journal of Sea Research* 36: 127-130.